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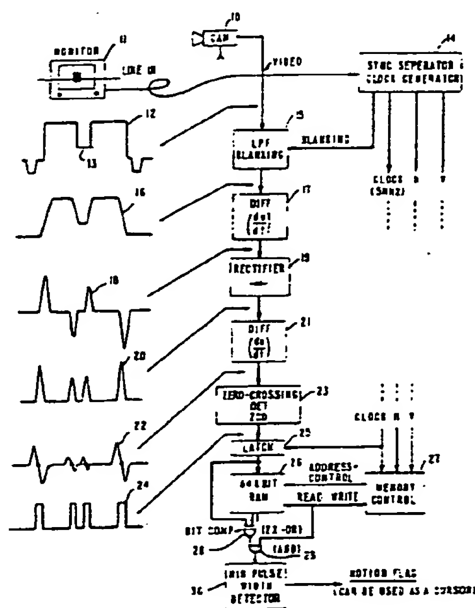
(54) Title: MOTION DETECTOR APPARATUS FOR RESPONDING TO EDGE INFORMATION CONTAINED IN A TELEVISION SIGNAL

(57) Abstract

A motion detector which responds to edge information contained in a television signal. Essentially, the motion detector processes the television signal to provide edge information by means of determining the zero cross over of the processed signal. The edge information is stored for a television field and then stored information is checked after a predetermined time. If some edges have changed position then this indicates the presence of motion. In this manner a single bit of information is sufficient to indicate the presence or absence of an edge. The motion detector includes a memory (26) which is capable of storing the edges of all possible locations of a television field. The memory address represents the location of the edge. In the circuitry only horizontal edges of one television field are stored and then compared with the transitions of one of the next comparable fields. Without motion the stored and actual edges have identical positions. The circuitry utilizes a bit comparator (28) which provides a motion flag if stored and actual edges do not coincide thereby indicating that motion occurred. This motion flag can trigger an alarm or be used as a cursor on a monitor to identify the area of motion.



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MOTION DETECTOR APPARATUS FOR RESPONDING TO EDGE INFORMATION CONTAINED IN A TELEVISION SIGNAL

BACKGROUND OF THE INVENTION

This invention relates to motion detection in a television picture that is contained in a television signal and more particularly to a motion detector which employs information included in the television signal and indicative of the edges of objects appearing in a televised scene.

The prior art is aware of the fact that a television signal contains information that is relative to the motion in the television picture content. Such techniques have been used in intrusion detection or video surveillance systems where it required to detect motion by examination of a video signal. A known method employed in the prior art compares a real time image with a delayed image from a previous field or frame which is stored in a memory.

In any event, such systems require a relatively expensive frame store memory which stores the video signal of an entire field or frame. The video signal that contains the picture information of the subsequent picture frame is compared with the stored video signal and the result of such comparison provides a signal indicative of motion. These systems operate on the fact that motion causes the content of pixels in a present video signal to be different from the corresponding pixels in the stored frame.

In any event, as one can imagine these systems have difficulties in that an expensive frame store is required. A further difficulty with such systems is that they are affected by changes in illumination which can cause false alarms.

Another prior art system employs the use of one or more windows of fixed and variable size which are placed somewhere in the television picture area to be observed. The average light level within the windows is then measured and stored in the memory. A short time later a second measurement is made and compared to the first one. If a person moved in the window between these times the first and

second measurements become unequal and an alarm is triggered. These systems do not require full frame storage but require substantial processing to define the window areas which may constitute many lines of a television picture. Again, these systems work satisfactorily under constant illumination conditions but they react to light changes thereby causing false alarms. It is also known that motion information is contained in the frequency spectrum of a television signal. See for example U.S. Patent No. 4,641,186 issued on February 3, 1987 to D.H. Pritchard and entitled MOTION DETECTOR THAT EXTRACTS MOTION INFORMATION FROM SIDEBANDS OF A BASEBAND TELEVISION SIGNAL and assigned to the RCA Corporation. See also a copending application entitled MOTION DETECTION APPARATUS EMPLOYING INFORMATION CONTAINED IN THE FREQUENCY SPECTRUM OF A TELEVISION SIGNAL by M.M.A. Megeid and filed on 29 JUNE 1987 Serial No. PCT/US87/01501 , and also assigned to the RCA Corporation.

These systems make use of the fact that the frequency spectrum of a television signal for a stationary picture consist of a series of components and harmonics of the horizontal and vertical scanning frequencies. In any event, the components of major magnitudes of the television signal spectrum are the DC component, the field frequency components and the components of the line frequency and its harmonics. Thus, surrounding each line frequency harmonic is a cluster of components each separated from the next by an interval equal to the field scanning frequency.

For a stationary picture the harmonics for example of the line frequency are fixed and are at integral multiples of the line frequency. However, when motion is present the spectral components contain additional sidebands due to the change of information from one field to the next. Essentially, these additional sidebands can be detected to provide a signal indicative of motion. Other systems which are more sophisticated use digitized video signals and require digital processing in computers for picture recognition. The tremendous data rate provided by a

television camera must first be reduced before it can be handled by the computer.

This adds cost and complexity to the systems. These systems are very flexible but a great deal of effort is needed to provide the proper software in order to provide digital processing as well as complicated and sophisticated digital compression techniques. Hence, these systems are extremely expensive.

In view of the above, it should also be apparent to those skilled in the art that there are many additional applications apart from surveillance where it is required to be able to detect motion by examination of a video signal. In any event, it is indicated that the apparatus employed with any such detection scheme should be economical, easy to implement and be reliable.

In this manner the television signal can be adequately employed to detect motion and hence used in conjunction with an intrusion detection system or other system to indicate the presence of such motion.

SUMMARY OF INVENTION

One aspect of the present invention is to provide a motion detector that employs edge information contained in the television signal to produce an output indicative of such motion. A further aspect of the present invention is to provide a motion detector which employs simple and economical circuitry capable of responding to the edges of an object and to determine when an object has moved by observing whether or not an edge of an object moves. The system generates an edge outline of an object and stores the same and then compares the next outline with the stored outline to determine motion.

It is a further aspect of the present invention to provide an inexpensive and reliable motion detector by extracting motion information indicative of object edges located in a picture and comparing this information as stored with information in a succeeding field or frame to determine

whether or not the edge or object pattern has changed due to the presence of motion.

BRIEF DESCRIPTION OF PREFERRED EMBODIMENT

Motion in a television picture which is indicative of a television signal can be detected by observing whether or not an edge of an object has moved within an area under surveillance. The apparatus thereby stores all edges of a television field and then proceeds to check the edges stored after a predetermined time. Based on this comparison, if edges have changed position then a signal is generated indicative of motion. The system enables one to store a single bit of information which is sufficient to indicate the presence or absence of an edge and therefore sufficient to indicate the presence or absence of motion. A 64 Kbit memory is utilized to store the edges of all possible locations in the television field. The memory address represents the location of the edge. In a simple embodiment only edges of one television field, for example an odd field are stored and compared with the edges of one of the next odd fields. Without motion, stored and actual edges have identical positions. A bit comparator yields a motion flag output if the stored and actual edges do not coincide thereby indicating that motion occurred. The motion flag, as will be explained, can trigger an alarm or can be used as a cursor on a monitor to identify the area of motion.

BRIEF DESCRIPTION OF THE FIGURES

Fig. 1 is a detailed block diagram showing a motion detector for responding to edge information according to this invention and further includes a series of timing diagrams depicting the various outputs of the circuitry shown in Fig. 1.

Fig. 2 shows waveforms illustrating a typical write/read compare sequence for the circuitry shown in Fig. 1.

Fig. 3 shows a series of timing diagrams depicting the various outputs concerned with processing the video signal to determine a zero cross over.

Fig. 4 again shows a signal as provided by the circuit of Fig. 1 to determine edge information based on the zero crossing time.

Fig. 5 shows a complete circuit schematic of an amplitude independent zero crossing detector as can be employed with this invention.

Fig. 6 shows a series of waveforms depicting the operation of the zero crossing detector of Fig. 5.

DETAILED DESCRIPTION OF THE INVENTION

Referring to Fig. 1, there is shown a detailed block diagram of a motion detector apparatus according to this invention.

In regard to Fig.1 there are a series of waveforms depicted on the left each of which is directed towards the output of particular modules designated in Fig. 1. These waveforms are indicative of the video or television signal as processed by the circuitry shown in Fig. 1 to produce motion detection by responding to edges of an object in a televised scene.

Referring to Fig. 1, there is shown a television camera 10. Essentially, the television camera 10 is a well known component and in this particular application serves to monitor a given area under surveillance to specify whether the area contains motion. Television cameras 10 are well known in the art and many suitable examples of such devices exist. Essentially, before proceeding with the description of the invention, it is noted that the invention pertains to any particular type of television system such as the NTSC System utilized in the United States or the PAL system utilized in Europe and elsewhere. Essentially, the differences between such systems are also well known. In the United States the frame frequency is 30 Hz (29.97) while in the PAL system it is 25 Hz. The frame period in the NTSC system is 33,333 microseconds while in the PAL system it is

40,000. The field frequency in the NTSC system is 60 (59.94) Hz while in Europe it is 50 Hz. The field period in the United States is 16,667 microseconds while in Europe it is 20,000 microseconds. The line frequency in the NTSC system is approximately 15,750 (15,734 +) Hz while in Europe it is 15,625 Hz. In any event, the specifications regarding the principal television systems employed throughout the world are well known and are available in many textbooks. See for example a text entitled <u>Television Engineering Handbook</u> by Donald G. Fink published by McGraw Hill Book Co., Inc.

Thus, as seen in Fig. 1, the output of the television camera 10 produces a typical video signal 12. For purposes of explanation a portrayal of the area scanned by the television camera 10 is shown in regard to the screen presentation of a typical television monitor or receiver 11. As one can ascertain, for purposes of explanation, the television camera 10 is surveilling an area which provides a simple scene comprising a white field with a grey square in its center. In this manner the line n as indicated in regard to the monitor 11 is selected to explain the function of the system.

As one can ascertain, the television signal output 12 provides the television picture as shown on monitor 11. The signal 12 essentially defines the white field with a central area 13 manifesting the grey square. The signal 12 is indicated in the diagram to the left of the block diagram to specify the output of the television camera 10. The video signal 12 is coupled to a module 14 designated as sync separator and clock generator. Essentially, the function of the module 14 also provides well known operations. As one can ascertain, the television signal contains both a vertical and horizontal signal which are combined within the television signal. The vertical and horizontal signals are typically extracted from the television signal by means of conventional sync separator circuits. There are many existing references which describe sync separation both for the horizontal and vertical signals and such techniques are well known.

Essentially, as indicated, one output from the sync separator 14 is the horizontal sync signal designated by the letter H while another output from the sync separator is the vertical sync signal designated by the letter V. The sync separator also operates as a clock generator and thereby produces a clock output at a frequency of approximately 5 MHz. This signal of approximately 5 MHz is a line locked clock frequency, and as will be explained, the clock frequency is used to drive the memory and should have a reasonable short term stability but not be crystal controlled. The value of approximately 5 MHz corresponds to 256 samples per active television line as will be further explained. The means of generating such a frequency are well known within the state of the art. In this manner as indicated above, for the NTSC system the horizontal scanning frequency is approximately 15,725 Hz. One can utilize conventional frequency multiplication techniques or utilize a phase locked loop to produce a signal which is close to 5 MHz. For example, by multiplying the horizontal line frequency by a factor of 318 or there abouts one could obtain a frequency which is close to 5 MHz and which is locked by means of a phase locked loop or other device to the line frequency. There are other techniques such as the use of frequency synthesizers and so on which will enable one to generate such a clock frequency with simple available circuitry. Hence, it should be clear to those skilled in the art that an output clock frequency derived from information contained in the video signal 12 is immediately available and can be easily generated.

The video signal 12 emanating from camera 10 is also applied to a lowpass filter and blanking circuit 15. As is also well known in the art, the sync separator 14 produces signals indicative of blanking. In this manner the sync signals are removed from the television signal and the video is applied to the lowpass filter 15. The output of the lowpass filter 15 is designated as waveform 16. The lowpass filter 15 is a conventional device and is required so that the Nyquist criterion which essentially corresponds to the 5

MHz sampling frequency is maintained. The lowpass filter can be further designed so that very fine details which may exist in the television signal concerning very small objects such as insects, raindrops and so on are completely suppressed.

As one can ascertain by comparing the signal 12 with the signal 16, the signal 16 has slower rise time and fall times associated with the edges indicative of the white field with the grey square in the center. The output of the lowpass filter 15 is applied to the input of a differentiator 17. The function of the differentiator 17 is to define the edges of the lowpassed video signal as shown by waveform 18. The output of the differentiator 17 is applied to the input of a rectifier circuit 19. The purpose of the rectifier 19 is to convert all negative going edges into a positive pulse signal. The rectifier is a conventional circuit and may be a full-wave rectifier which is well known in the art.

The output of the rectifier 19 is applied to the input of a second differentiator 21 whereby the second differentiator 21 provides a pulse signal indicative of the zero crossings of the pulse edges as shown in waveform 22. The darker dots associated with the waveform 22 indicate zero crossings. The output of the differentiator 21 is applied to the input of a zero crossing detector (ZCD) 23. The function of the zero crossing detector 23 is to detect the zero crossings of the signal 22. Zero crossing detectors as 23 are also known in the art. In any event, a particular example of a suitable zero crossing detector 23 will be given subsequently.

The output of the zero crossing detector is applied to the input of a latch 25. The latch 25 receives the 5 MHz clock from the sync separator and clock generator 14 and hence synchronizes the zero crossing outputs with the 5 MHz clock. The output of the latch 25 is applied to the input of a 64 kbit memory or RAM 26. The 64 kbit memory is selected to accommodate 256 lines and 256 samples per line. Hence, the memory 26 is able to store the edges of all possible locations of a television field.

As seen in Fig. 1, the memory 26 is controlled by a memory control circuit 27. Essentially, the memory control circuit 27 receives the 5 MHz clock and the horizontal and the vertical sync signals. As one can ascertain, the memory control may include a line counter whereby each line in a television field is counted by responding to the horizontal sync pulse. The television fields are also counted by means of a field counter which is responsive to the vertical sync pulse. Counters which operate and are synchronized by horizontal and vertical sync signals are well known in the art and are used widely in digital circuits for converting a television field or frame to pixels. Hence, each line in a particular field is represented by 256 separate storage locations in memory 26. In any event, the memory control 27 produces a series of addresses for each line and at each address a particular pulse as shown in waveform 24 is stored at a binary 1 or 0 indicative of a crossover. Each stored pulse represents an edge of a viewed object. The memory control also produces as will be explained a synchronous read and write signal to enable the latched zero crossings to be applied at the appropriate address in the memory.

Referring to Fig. 2, there is shown a typical write-read/compare sequence. As seen in Fig. 2, the edges of field n are stored (written into memory) and read out and compared to the new values during the field n+2 by means of the exclusive OR gate 28. The OR gate 28 functions as a bit comparator and compares the value stored in memory with the value for a successive field as field n+2. The AND gate 29 which is connected to the exclusive OR gate 28 enables the output only during the read/compare time. It is noted that the typical sequence shown in Fig. 2 can be modified. The wait time can be expanded to 3, 5, 7...fields respectively if very slowly moving objects are to be detected. The output of the AND gate 29 is applied to a minimum pulse width detector 30. The output of this detector 30 is designated as motion flag and essentially can also be used as a cursor. The reason why the output of the minimum pulse width detector 30 can be used as a cursor is that one has information regarding

the exact position of each edge as stored. Each edge as indicated above has a unique address in regard to a television line and in regard to 1 out of 256 positions on the line.

Hence when the minimum pulse width detector 30 provides an output, the circuit via the address can indicate where that position is in regard to the television picture. Hence, the output of the minimum pulse width detector can be used as a cursor to provide increased illumination on the display indicating the exact area where motion occurred or can be used in conjunction with the address to print out or otherwise display the particular area on the television screen where motion has occurred.

Referring to Fig. 3, some of the characteristics of the zero cross-over detector will be explained and described. As indicated, the zero cross-over detector 23 operates to detect the zero crossings of the signal 22 as applied to its input.

Shown in Fig. 3a are two waveforms 40 and 41 which essentially represent the same edge but at different values of illumination. As one can see from Fig. 3A, the zero crossing points at the input of the zero crossing detector do not change position in time should the level of the video signal vary due to illumination changes. In any event, the signals 40 and 41 represent the exact zero cross-over but at different illuminations. The signal 40 is of an increased scene illumination as compared to the signal 41.

Due to noise in the video signal the input signal of the zero crossing detector 23 is slightly irregular resulting in a possible jitter of one clock cycle of the two pulses to be compared in the external OR gate 28. The jitter is shown in Fig. 3A. Assume that there is no motion and the input signal of the zero crossing detector 23 crosses zero at time T1 in field n. The output of the zero crossing detector is then latched at time T2 and stored in the memory. As one can see, Fig. 3B represents field n while Fig. 3C represents field n+1. Figure 3D shows the 5 MHz clock signal in regard to the field signals while Fig. 3E shows the latch output for

field n and Fig. 3F shows the latch output for field n+1. Figure 3G shows the output of the exclusive OR gate 28 which is the bit comparator as it serves to compare the stored value of field n with that of field n+1. Figure 3H shows the output of the minimum pulse width detector.

In any event, the operation due to jitter is as follows. As indicated, if one assumes no motion and one further assumes that the input signal of the zero crossing detector crosses zero time T1 in field n, the output of the zero crossing detector is then latched at time T2 and stored in memory. Two fields later in the read/comparison sequence, the input of the zero crossing detector may cross zero at time T3 due to noise or jitter. As a result, the output of the zero crossing detector is latched at time T4 and the exclusive OR gate as gate 28 yields two pulses each one clock cycle wide thereby indicating motion. This of course would be a false output.

In any event, as one can see from Fig. 3G, these two pulses can be discriminated against by adding a minimum pulse width detector circuit as circuit 30 shown in Fig. 1. This circuit only yields a signal if its input signal has a minimum width of two clock cycles thereby avoiding false alarms due to noise. As one can immediately understand based on the waveforms shown in Fig. 3G, the minimum pulse width detector can comprise one shots and AND gates or some other conventional circuit arrangement.

As one can ascertain from Fig. 3G, the pulse width detector will only produce a pulse output if there is a continuous high level. As one can ascertain from Fig. 3G such a level does not exist between T_5 and T_4. The absence of a pulse in this duration can be easily detected.

In any event, as one can ascertain from Fig. 3G, if there was a substantial change in the edge signal between field n and field n+1 then the overlap would be substantial and a longer width pulse would be provided. It is of course understood that there are many other techniques for providing an output signal based on a minimum width of a pulse to thereby avoid false alarms due to noise.

As indicated from the above, one can ascertain that the zero crossing detector as for example detector 23 shown in Fig. 1, should preferably operate to have a jitter free determination of the zero crossing of a waveform. As one can ascertain from Fig. 4, there is shown the input signal to the zero crossing detector 23 as for example that signal 22 as shown in Fig. 1. In any event, as was explained above, if scene illumination changes, the amplitude of the signal changes but the cross over in regard to the axis does not change.

As again shown in Fig. 1, the signal applied to the input of the zero crossing detector is prepared by utilizing a lowpass filter, double differentiation and full wave rectification to give the waveform shown in Fig. 4 which is analogous to the waveform shown in Fig. 1 as waveform 22. It is noted that the rectifier shown in Fig. 1 is not an essential feature but is a convenient means for providing a constant polarity waveform for the second differentiator 21 and the zero crossing detector 23. In any event, a suitable zero crossing detector is shown in detail in Fig. 5. As indicated the characteristic of the waveform shown in Fig. 4 is that the center point or zero crossing does not move on the time axis as the amplitude of the signal changes due to scene illumination.

Zero crossing time is detected using the circuit shown in Fig. 5. A comparator 50 which may be a conventional type comparator such as the LM360 has an input which is AC coupled to the signal emanating from the output of the differentiator 21 via capacitor 51 designated as C_1. One output of the comparator which is designated as Q is coupled back to the inverting input through a feedback resistor 54. This feedback provides a small amount of hysterisis such that the comparator will only trigger when the leading edge of the input waveform exceeds a value preset with the variable resistor 53. In practice an offset of 10 millivolts was shown to give good immunity against false triggering on noise without losing sensitivity. This first upper switching level

will have timing variations in response to the amplitude of the signal. See Fig. 6A.

It is noted that the comparator 50 is on whereby the $\overline{Q}$ output will be at near zero volts and the offset bias will also be zero. The comparator 50 will thus trigger off when the input signal changes polarity or essentially at the zero crossing point. Measurements on the circuit depicted in Fig. 5 shows that the timing error at the zero crossing was less than 20 ns with a signal level change of 6 to 1. This means that the requirements for the motion detector with a large safety margin are completely met. The Q or $\overline{Q}$ output of the comparator is used to trigger a one shot 60 that provides the desired jitter free outline signal (Fig. 6E).

Again referring to Fig. 6, Fig. 6A shows two signals A and B either of which can be applied to the input of the comparator via capacitor 51. Signal A represents edge information of a scene having a greater illumination than Signal B. It is noted that both signals essentially provide the same zero cross over. Figure 6B shows the $\overline{Q}$ output from the comparator based on an upper switching level as shown. The comparator output signal produces a positive transition exactly at the zero cross over.

Figure 6C shows the waveform at the input to the inverting terminal (eHYST) of the comparator while Fig. 6D shows the Q output of the comparator. It is noted that either of the trailing edges of waveforms B and D can be used to trigger the one shot 60 to produce the output signal TOS which is of a constant duration and a selected pulse width. It is noted that this comparator provides a jitter free determination of the zero crossing of the applied waveform.

Based on the above, it should be apparent to those skilled in the art that the circuitry and techniques described offer many advantages. Essentially, while the structure requires the use of a memory, it is immediately understood that the memory only has to store one bit indicative of the existence or presence of edges of objects along the television line. This completely eliminates the need for processing a television picture into pixels using

analog-to-digital conversion and digital-to-analog conversion.

The storage capability of the memory is greatly reduced as compared to prior systems. In any event, the number of edges that can be achieved and stored by this system is more than sufficient to determine the outline of all objects under surveillance and to further determine whether or not an outline has shifted or whether or not an object in the televised scene has moved. Hence, the output of the circuit, namely the motion flag can be utilized to trigger another surveillance device as for example an additional video camera or couple the present camera to a video tape recorder or other storage device. In this manner the motion flag can trigger a tape recorder to provide storage of the television picture when a motion condition is detected. It is, of course, understood that the circuitry as above-described is extremely simple as compared to other circuitry employed in surveillance systems.

It is also understood that while the above-noted example indicated storage of edges for a complete television field, one can store edges for particular sets of lines or particular sets of portions of line as windows and so on which windows are then monitored by means of storing edges as described above for each particular area of a television picture under observation. In this manner one can substantially reduce the storage requirements of the system.

In any event, as one can see and ascertain from the above, it is immediately understood that the components such as memory 26 of Fig. 1 are available from many commercial entities and is relatively inexpensive. Accordingly, by reviewing the above-noted specification, one skilled in the art should discern a wide variety of alternatives without departing from the spirit and scope of the invention as claimed.

WHAT IS CLAIMED IS

1. A motion detector apparatus of the type responsive to a television signal indicative of a television picture with said signal generated by a television camera monitoring an area under surveillance, said area containing objects which under a surveillance mode should remain stationary, comprising:

means responsive to said television signal to store the edge information indicative of given object location during a first timing interval,

and operative to generate edge information for a successive timing interval and including comparison means to compare said stored edge information with said generated edge information at said given object locations to provide an output signal representative of a change in said edge information between said intervals and indicative of motion in said area under surveillance.

2. The motion detector apparatus according to Claim 1, wherein said first timing interval is a television field and said successive timing interval is a successive comparable field.

3. The motion detector apparatus according to Claim 1, wherein said means responsive to said television signal includes a memory having a plurality of storage locations each location operative to store edge information indicative of an associated television line and a sampled area within said line to thereby store in each associated location edge information of each line as sampled during said first timing interval.

4. The motion detector apparatus according to Claim 3, wherein said memory is a RAM memory having said plurality of storage locations for storing 256 samples for each of 256 television lines.

5. The motion detector apparatus according to Claim 1, wherein said means responsive to said television signal includes,

a low pass filter means having an input for receiving said television signal to provide at an output a

low passed television signal indicative of a given sampling rate,

a first differentiator coupled to said lowpass filter output for providing a differentiated signal manifesting a series of bipolar pulses indicative of edge information,

rectifier means coupled to said first differentiator for providing a pulse train of a given polarity indicative of said edge information in said differentiated signal,

a second differentiator coupled to said rectifier means for providing a second differentiated signal with specified zero cross over indicative of edge information in said rectified signal,

a zero crossing detector responsive to said second differentiated signal to provide a first binary value for a zero cross over and a second binary value for the absence of a cross over,

a memory coupled to said detector and operative to store said first binary values in given locations indicative of edge information in said television signal during said first timing interval.

6. The motion detector according to Claim 5, further comprising:

memory control means coupled to said memory for providing address information for said memory indicative of a selected number of horizontal lines in a television picture to enable said memory to store in the associated memory locations all edge information associated with said addressed line, whereby said memory has stored therein edge information for each selected number of lines within a plurality of locations associated with each line.

7. A motion detector apparatus of the type responsive to a television signal indicative of a television picture, with said signal generated by a television camera monitoring an area under surveillance, said area containing objects which under a surveillance mode should remain stationary, comprising:

first means responsive to said television signal for providing at an output a series of pulses indicative of the edge outline of selected objects in said area under surveillance for each of a given number of television lines during a given interval timing,

differentiator means responsive to said series of pulses for providing at an output a differentiated waveform for each given number of television lines manifesting distinct zero crossings,

a zero crossing detector means responsive to said differentiated waveform and operative to provide a series of pulses at an output indicative of said zero crossing information for each television line,

memory means coupled to said zero crossing detector means for storing said pulse information for each television line in separate locations during said given timing interval,

comparator means coupled to said memory means and operative to compare said stored information with pulse information generated during a successive given timing, interval to provide an output alarm signal if said information as stored does not compare with said generated information said alarm signal indicative of motion in said area.

8. The motion detector apparatus according to Claim 7, wherein said first means comprises:

lowpass filter means responsive to said television signal to provide at an output a lowpassed version thereof,

differentiator means coupled to said lowpass filter means to provide at an output a differentiated signal,

rectifier means coupled to said differentiator means to provide at an output a series of pulses of a given polarity from said differentiated signal and indicative of said edge outline of said objects.

9. The motion detector apparatus according to Claim 8, further including:

sync separator means responsive to said television signal to provide at one output a horizontal sync signal, at a second output a vertical sync signal and at a third output a clock signal having a repetition rate indicative of a sampling rate for each television line.

10. The motion detector apparatus to claim 9, further including:

memory control means having inputs coupled to said sync separator means outputs and outputs coupled to said memory means and responsive to said horizontal sync, vertical sync and said clock signal to provide at a first output a series of addresses each indicative of a television line and a sampling interval on said line for addressing said memory to enable storage of said information in selected memory locations and further including means for controlling said memory means to read or write said stored information.

11. The motion detector according to Claim 10, further including latching means having one input coupled to the output of said zero crossing detector means and one input coupled to said clock output of said sync separator means and operative to provide at an output said series of pulses indicative of zero crossing information synchronized to said clock.

12. The motion detector apparatus according to Claim 11, wherein said comparator means includes a bit comparator gate having one input responsive to a stored value and another input responsive to said generated value to provide at an output a signal indicative of an edge comparison for no motion or a signal indicative of a non-edge comparison for motion.

13. The motion detector apparatus according to Claim 12, further including a minimum pulse width detector means included in said comparator means and operative to provide said alarm signals only for predetermined width output signals from said comparator means.

14. A method of detecting motion by responding to a television signal generated by a television camera monitoring an area under surveillance with said area

containing objects which under a surveillance mode should remain stationary, comprising the steps of:

storing in memory a plurality of samples for each of a given number of television lines with each sample stored indicative of object edge information for each television line during a first television timing interval,

generating a second plurality of samples for each given number of television lines during a second successive television timing interval with each sample generated indicative of the same edge information as stored,

comparing said stored samples with said generated samples to determine whether a movement of an edge has occurred between said intervals,

providing an output signal upon determination of a movement of an edge and indicative of motion in said area.

15. The method according to Claim 14, wherein said first television timing interval is a television field with said second successive timing interval being one of a following comparable field.

16. The method according to Claim 15, wherein each television line is sampled a given number of times to provide a plurality of sampled areas for each line, with each area capable of providing edge information to be stored.

17. The method according to Claim 16, wherein the step of generating said second plurality of samples includes differentiating said television signal to provide a differentiated output signal,

rectifying said differentiated signal to provide a pulse signal of a given polarity with each pulse indicative of edge information along a television line,

differentiating said pulse signal to provide a differentiated signal having distinct zero crossings,

detecting said zero crossing to provide a signal having a first binary value for a zero crossing and a second value for the absence of a crossing .

18. The method according to Claim 17, further including the step of identifying each stored sample as

stored in memory according to a given television line indication and to a given area on said line whereby each sample stored can be identified accordingly.

19. The method according to Claim 18, further including the step of identifying given samples stored which indicate a movement of an edge when said output signal is provided to enable one to locate the area of movement in said television picture.

20. An amplitude independent zero crossing detector apparatus for detecting the zero crossing of a waveform applied to an input thereof comprising:

a comparator circuit having a first non-inverting input and a second inverting input, and having an output, means for AC coupling said waveform to said first input,

a feedback resistor coupled from said output to said inverting input to provide hysterisis to said comparator such that said comparator will only trigger when the leading edge of said waveform exceeds a value as preset by means of said given resistance value.

FIG. 1

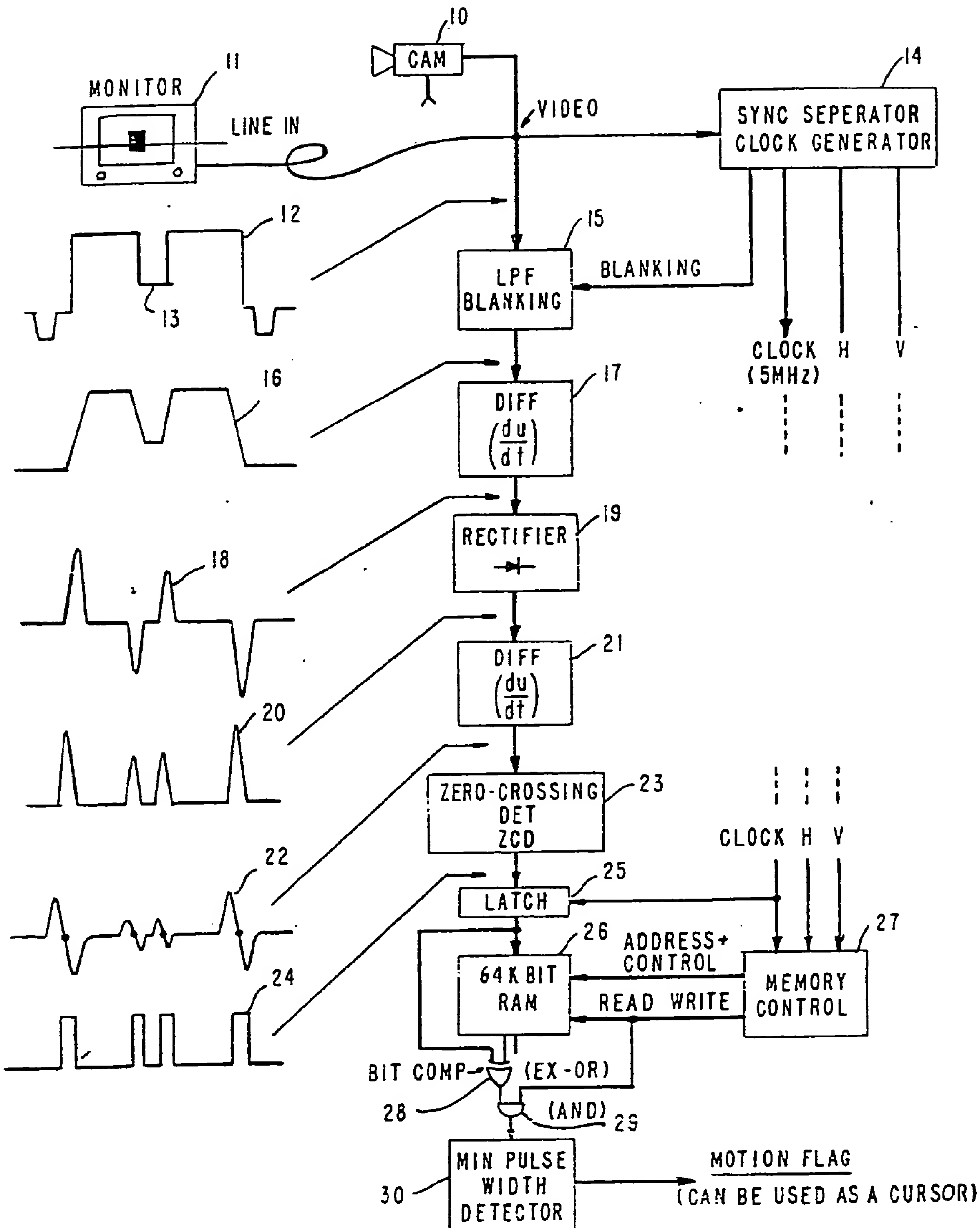

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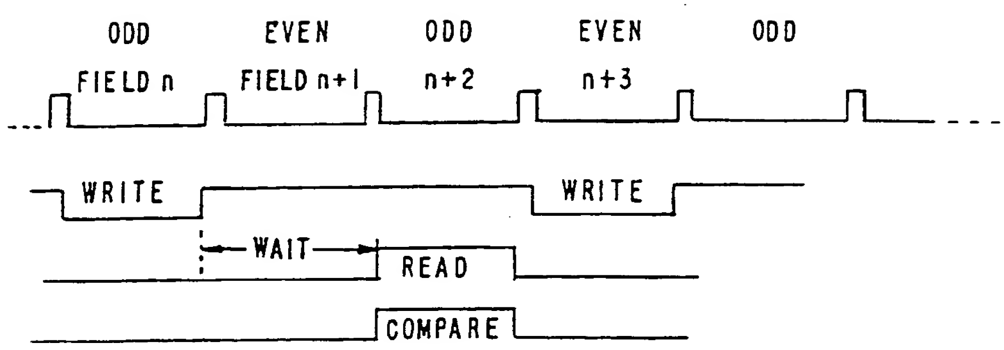
FIG. 2


ODD
FIELD n
EVEN
FIELD n+1
ODD
n+2
EVEN
n+3
ODD
WRITE
WRITE
WAIT
READ
COMPARE

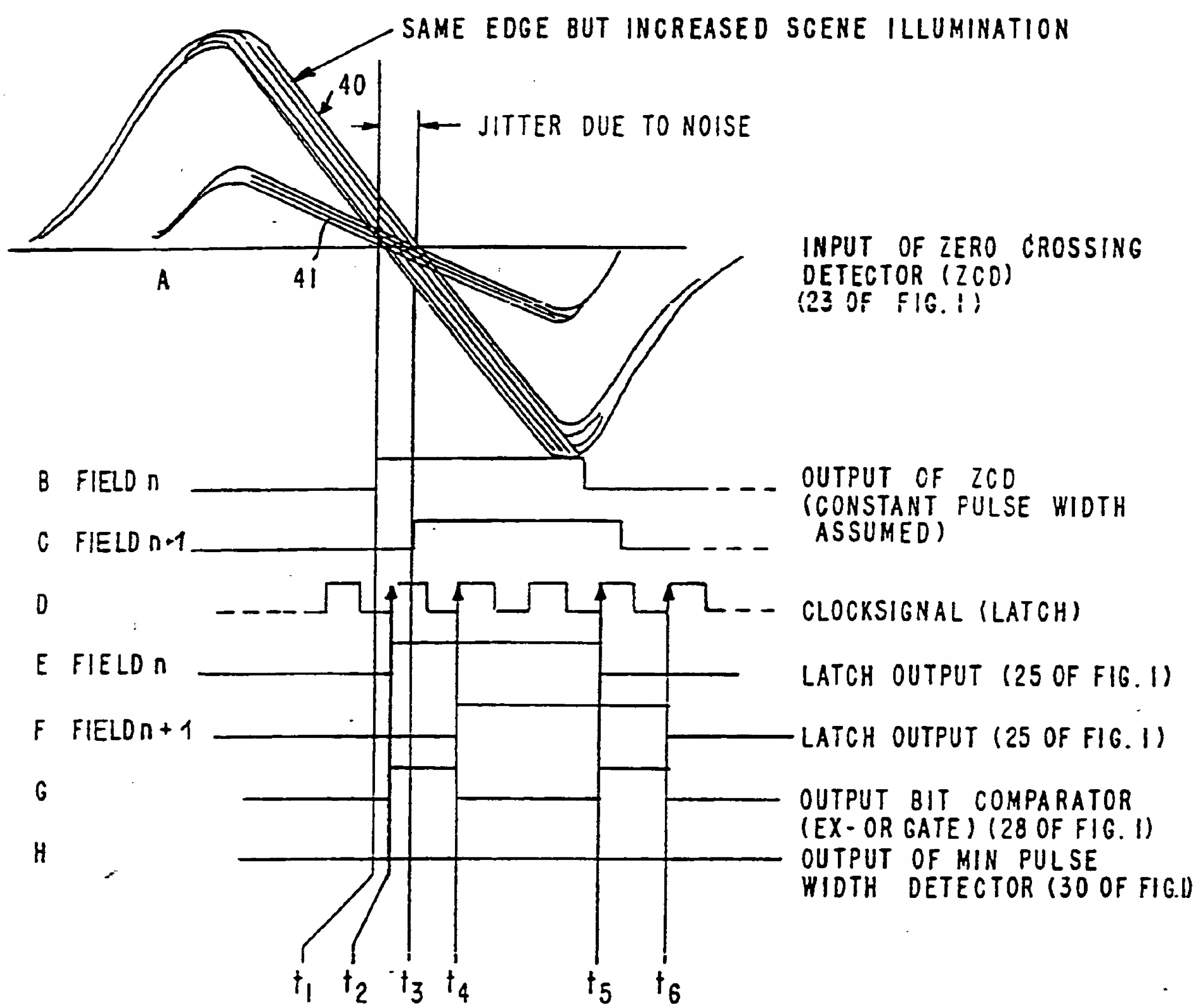

SAME EDGE BUT INCREASED SCENE ILLUMINATION
40
JITTER DUE TO NOISE
A
41
INPUT OF ZERO CROSSING DETECTOR (ZCD) (23 OF FIG. 1)
B FIELD n
C FIELD n+1
D
E FIELD n
F FIELD n+1
G
H
OUTPUT OF ZCD (CONSTANT PULSE WIDTH ASSUMED)
CLOCKSIGNAL (LATCH)
LATCH OUTPUT (25 OF FIG. 1)
LATCH OUTPUT (25 OF FIG. 1)
OUTPUT BIT COMPARATOR (EX-OR GATE) (28 OF FIG. 1)
OUTPUT OF MIN PULSE WIDTH DETECTOR (30 OF FIG.1)
t_1 t_2 t_3 t_4 t_5 t_6

FIG. 3

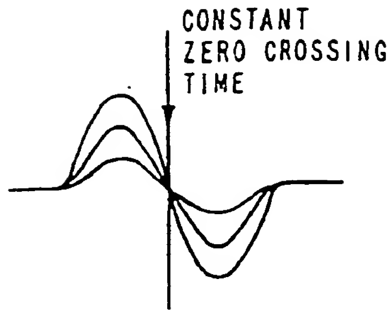


FIG. 4

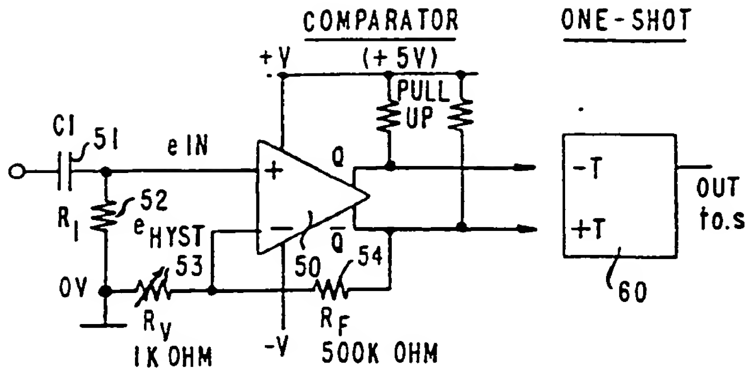


FIG. 5

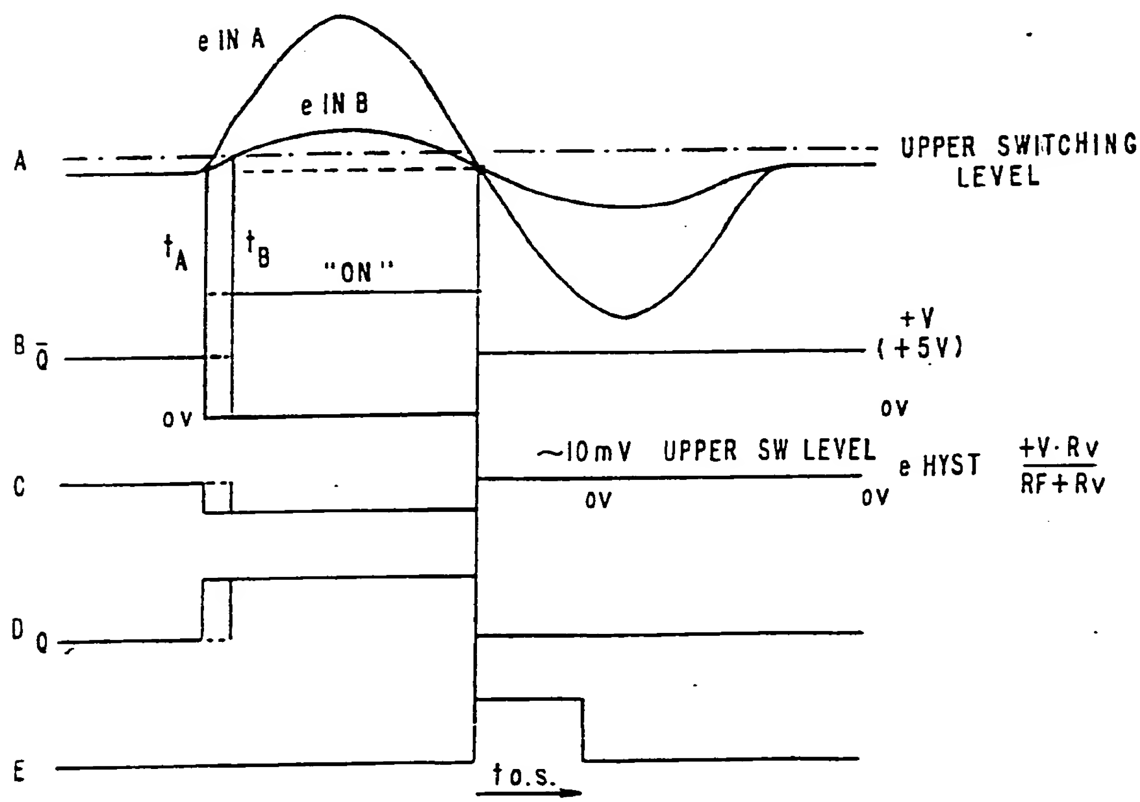


FIG. 6

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INTERNATIONAL SEARCH REPORT

International Application No PCT/US87/01485

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC(4): H04N 7/18

U.S. CL. 358/105,108; 307/354

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
U.S.	358/105,108,96,125,31,136,126; 307/354

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
Y	US, A, 4,546,383 (Abramatic) 08 October 1985, See entire document.	1-4,14-16
Y	US, A, 4,160,998 (Kamin) 10 June 1979, See entire document.	1-4,14-16
Y	US, A, 4,270,143 (Morris) 26 May 1981, See entire document.	1-4,14-16
P,A	US, A, 4,597,010 (Carr) 24 June 1986.	
Y	US, A, 3,718,864 (Kelly) 27 February 1973, See entire document.	20
Y	US, A, 4,157,509 (Zielinski) 05 June 1979, See entire document.	20
P,Y	US, A, 4,644,188 (Grib) 17 February 1987, See entire document.	20
Y	US, A, 3,916,328 (Wilson) 28 October 1975, See entire document.	20

(Continued)

* Special categories of cited documents: [15]
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
22 August 1987	29 SEP 1987
International Searching Authority [1]	**Signature of Authorized Officer [20]**
ISA/US	Victor R. Kostak

Form PCT/ISA/210 (second sheet) (October 1981)

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category*	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No [18]
Y	US, A, 4,068,138 (Miyakawa) 10 January 1978, See entire document.	20

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

V.☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [10]

This International search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1.☐ Claim numbers ...., because they relate to subject matter [12] not required to be searched by this Authority, namely:

2.☐ Claim numbers ...., because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out [13], specifically:

VI.☒ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [11]

This International Searching Authority found multiple inventions in this International application as follows:

I. Claims 1-19 drawn to a motion detector classified in class 358/105.

II. Claim 20 drawn to a zero-crossing detector, classified in class 307/354.

1.☒ As all required additional search fees were timely paid by the applicant, this International search report covers all searchable claims of the international application.

2.☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3.☐ No required additional search fees were timely paid by the applicant. Consequently, this International search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4.☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☒ No protest accompanied the payment of additional search fees.